SEARCH FOR SHORT-TIME PERIODIC VARIATIONS AMONG WR+C BINARIES

S.V. MARCHENKO[1] *, I.I. ANTOKHIN[2], J.-F. BERTRAND[1], R. LAMONTAGNE[1], A.F.J. MOFFAT[1], A. PICENO[3] and J.M. MATTHEWS[4]

[1] *Département de Physique, Université de Montréal, C.P. 6128, Succ. A, Montréal, Québec, H3C 3J7 Canada, and Observatoire du mont Mégantic*

[2] *Sternberg Astronomical Institute, Universitetskij Prospect 13, 117234, Moscow, Russia*

[3] *Instituto Nacional de Astrofisica, Optica y Electrónica, Apdos. Postales 216 y 51, Puebla 72000, Pue., México*

[4] *Department of Geophysics and Astronomy, University of British Columbia, 129-2219 Main Mall, Vancouver, BC, V6T 1Z4, Canada*

Abstract. During the 1992-1993 observing season, WR3, 6, 16, 40, 66, 82 and 134 were monitored in fast photometry mode with time-resolution 0.005–0.01 s. Only WR6 reveals a possible period of $P = 0.11$ s (semi-amplitude $A = 0.025$ mag), which is close to the derived equilibrium period of a new-born pulsar in a binary system after the rapid phase of Roche Lobe Over-Flow from the original secondary component.

1. Introduction

Few serious efforts have been carried out so far to observe the possible pulsed radiation ($0.^s1 \leq P_{rot} \leq 1^s$) from Wolf-Rayet + neutron star (WR+NS) systems. The only searches that have been made with sufficiently high time-resolution, $\Delta t \leq 0.^s1$, are those by Antokhin *et al.* (1982) and Zhilyaev *et al.* (1991, and these proceedings). Other photometric surveys devoted to fast variations in WR stars have too low time-resolution, $5^s \leq \Delta t \leq 2^{\min}$ (Moffat & Haupt 1974; Lindgren *et al.* 1975; Jeffers *et al.* 1985; Lamontagne & Moffat 1986). The results of all the above mentioned surveys were generally negative, possibly excluding $P \sim 150 - 200^s$, confirmed by independent observations in γ Vel (Jeffers *et al.* 1985).

2. Observations and results

Searches for ultra-rapid ($\Delta t = 0.005$ or 0.01 s) variations among the brightest WR+NS candidates were carried out in 1992-1993 from three sites: (a) in June-July 1992 from San Pedro Martir (*SPM*) Observatory (México), 0.84m telescope + double-channel photometer, narrow-band filters ($\lambda_o = 4700$ Å, FWHM = 190 Å; $\lambda_o = 5185$ Å, FWHM = 250 Å); (b) in November 1992 - January 1993 from Tonantzintla Observatory (México), 1m telescope + double-channel photometer, integral light; and (c) in February-May 1993

* On leave from Main Astronomical Observatory of the Ukrainian Academy of Sciences, Goloseevo, 252127 Kiev, Ukraina

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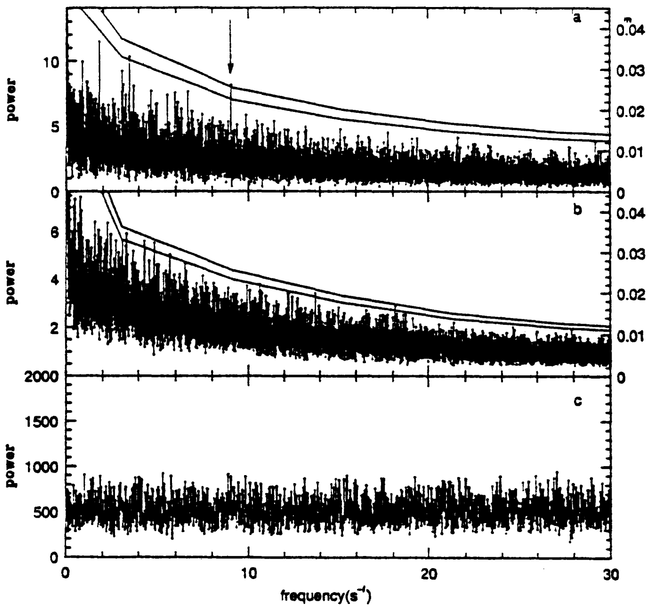

Fig. 1. The mean power spectra of: (a) EZ CMa, 9 nights; (b) comparison star, 18 records during 9 nights; (c) a night sky, 9 records. The 99.5% (upper full lines) and 99% (bottom lines) detection limits are given in accordance with Bendat & Piersol (1986). $P = 0.11$ s is marked by arrow.

from *CTIO*, Chile, 0.6m telescope + Automatic Single Channel Photometer, narrow-band v ($\lambda_o = 5990$ Å, FWHM = 69 Å) and broad-band V filters.

The following WR stars (all WN) were observed together with comparison stars at ultra-high time-resolution, $\Delta t = 0.005 - 0.01$ s, one (3-5) min scan/night, 4-20 nights of observations: WR3, 6, 16, 40, 66, 82, 134. Among them, WR3, 6, 16, 40, 134 have been previously mentioned as candidates for WR+c systems; WR66 and WR82 were added as two extra WN8 stars which are known to be highly variable as a class (Lamontagne & Moffat 1987), possibly as a result of the presence of a NS. Calculations of the mean power spectra (following the algorithm of Bendat & Piersol 1986) show that periodic variability in WR3, 16, 40, 66, 82 and 134 is entirely lacking. One can derive the following upper limits of periodic variability for the frequency range $f = 0.01 - 50$ or 100 Hz, depending on the time sampling interval: 7 mmag for WR3; 9 mmag for WR16; 7 mmag for WR40; 16 mmag for WR66; 15 mmag for WR82 and 2–4 mmag for WR134.

The situation for WR6 is less clear. There is no trace of periodicity in the Tonantzintla observations. However, the *CTIO* mean power spectrum (Fig. 1), as well as some individual ones, develops one distinct peak at $f = 9.048 \pm 0.003$ Hz with semi-amplitude $A \simeq 25$ mmag. Among the 14 observed stars (including the comparison stars), this is a unique case when the amplitude of a periodicity exceeds the 99.5% detection limit. Note that the atmospheric conditions of the Tonantzintla observatory are much less favorable for any kind of photometry than the *SPM* and Chilean ones.

3. Discussion

To be detected under the conditions of our 1992-1993 observations, the amplitude of the pulsed radiation must exceed the $\sim$ 1% detection limit, *i.e.*, during the main pulse, the pulsar luminosity must be at least: $L \approx 0.01 L_{WR} = 3 \times 10^{35} - 4 \times 10^{36}$ erg s^{-1}. As was shown by Marchenko *et al.* (1994), sufficient power can be generated by two mechanisms: (1) inverse-Compton radiation, when the beam of the high-energy particles generated in the NS magnetosphere is scattered by small-scale inhomogeneities (clumps) of the WR-star wind; and (2) coherent curvature radiation, when bunches of particles are created by electron $\rightarrow \gamma$-ray $\rightarrow$ electron+positron $\rightarrow$... conversion (Sturrock *et al.* 1975).

The final equilibrium rotational period, $0.1 \leq P_{rot} \leq 1$ s of the NS in the WR+NS system can be calculated after accounting for the various evolutionary stages (van den Heuvel 1977): (a) accretion by the new-born NS of the wind from the OB companion; (b) RLOF by the OB companion and supercritical (?) accretion; and (c) accretion of the wind from the WR companion. The possible $P = 0.11$ s spin period in WR6 is located at the upper border of P_{rot}, which may indicate an age for the pulsar of several 10^4 yr. This would make WR6 the best candidate for a WR+NS system besides Cyg X-3.

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